Dietary intake in Australian children aged 4-24 months: Consumption of meat and meat alternatives

Short title: Meat and meat alternative intake in children

Keywords: Meat/meat alternatives, dietary intake, infant, children

Mauch, Chelsea Emma[1]§
Perry, R A [1]
Magarey, A M[1]
Daniels, L A[2]

[1] Nutrition and Dietetics, School of Medicine, Flinders University, Adelaide, South Australia, Australia

[2] Exercise and Nutritional Sciences, Queensland University of Technology, Brisbane, Queensland, Australia

§ CEM: chelsea.mauch@flinders.edu.au

Nutrition and Dietetics, School of Medicine, Flinders University, Bedford Park, South Australia, Australia, 5042

Phone: +61 8 8204 6304

Fax: +61 8 8204 6406

RAP: r.perry@flinders.edu.au

AMM: anthea.magarey@flinders.edu.au

LAD: l2.daniels@qut.edu.au

Abstract:

Meat/meat alternatives (M/MA) are key sources of iron, zinc and protein, but intake tends to be low in young children. Australian recommendations state that iron-rich foods, including M/MA, should be the first complementary foods offered to infants. This paper reports M/MA consumption in Australian infants and toddlers, compares intake with guidelines and suggests strategies to enhance adherence to those guidelines. Mother-infant dyads recruited as part of the NOURISH and SAIDI studies provided three days of intake data at three points; Time 1 (n=482, mean (SD) age 5.5 (1.1)months), Time 2 (n=600, 14.0 (1.2)months) and Time 3 (n=533, 24 (0.7)months). Of 170 infants consuming solids and aged greater than six months at Time 1, 50 (29%) consumed beef, lamb, veal (BLV) or pork on at least one of three days. Commercial infant foods containing BLV or poultry were the most common form of M/MA consumed at Time 1, whilst by Time 2 BLV mixed dishes (including pasta bolognaise) became more popular and remained so at Time 3. The processed M/MA increased in popularity over time, led by pork (including ham). This study shows that M/MA are not being eaten by Australian infants or toddlers regularly enough or in adequate quantities to meet recommendations, and that the form in which these foods are eaten can lead to smaller M/MA serve sizes and greater sodium intake. Parents should be encouraged to offer M/MA in a recognisable form, as one of the first complementary foods, in order to increase acceptance at a later age.

Introduction:

The dietary intake of infants and toddlers is not well documented, and until recently there has been a lack of dietary recommendations against which to evaluate intake[1]. The World Health Organization broadly recommends that in order to meet energy and nutrient requirements, breastfed infants must be offered a varied diet including meat, poultry, fish and eggs along with a range of fruit and vegetables from around six months of age[2], however there remains little guidance regarding specific foods and quantities for children under the age of two years. In 2011 the food modelling system that underpins the Australian Dietary Guidelines was revised to incorporate the 2006 revised Nutrient Reference Values for Australia and New Zealand[3]. This modelling provides food consumption patterns that "deliver the nutrient requirements for people of varying age/gender, activity levels and life-stages"[3]. An important addition to this revision are dietary recommendations for infants and toddlers, presented in three age groups, 0 to 6 months, 7-12 months and 13-24 months.

Iron is one of the key limiting nutrients in the diets of young children primarily due to an increased requirement during this period of growth and to the fluctuations of food intake at this time[4,5]. Both iron deficiency and iron deficiency anaemia can lead to changes in behaviour, impaired immune function and delayed growth and development[6]. The incidence of iron deficiency in infants and young children in Australia has been reported to range between 5.4% in nine to 23 month olds[7] and 25% in six to 24 month olds[4], depending upon the cut-offs used to define iron deficiency. In the UK, a recent national survey of infants and children aged four to 18 months showed that 7% of five to 11 month olds and 11% of 12 to 18 month olds had depleted iron stores (serum ferritin levels below 9µg/L for five to six month olds, 5µg/L for seven to nine month olds and 12µg/L for those aged 10 months and over)[8]. Iron deficiency anaemia however tends to be less common in both Australia and the UK[4,7-9].

Meat is a highly bioavailable source of iron, but intake tends to be low in infants and toddlers[10-12]. A US study team found that only 14% and 12% of male and female two- to five-year-olds consumed the recommended amount of meat over three consecutive days[13]. A positive association has been observed between the iron status of infants at 15 and 18 months of age and the consumption of meat, fish and poultry[14]. Gaining a better understanding of meat (and meat alternatives) consumption in infants and toddlers in Australia is an important step towards ensuring that nutritional needs for healthy growth and development are met.

Two large-scale infant nutrition studies in Australia have recently collected comprehensive dietary intake data on infants and toddlers; the NOURISH trial[15] and South Australian Infants Dietary Intake (SAIDI) study[16]. Mother-infant dyads were recruited at infant birth and dietary intake data were collected at three points between four and 24 months. This comprehensive data set and newly developed national healthy eating guidelines present an opportunity to describe and evaluate the meat and meat alternative intake of Australian infants and toddlers.

The aim of this paper is to report the patterns of meat and meat alternative (M/MA) consumption in Australian infants and toddlers and to compare intake with recent recommendations[3]. The main sources of M/MA in the diet will be identified and strategies to ensure M/MA intake meets current guidelines will be suggested.

Methods:

The sample:

The sample comprises two distinct sub-sets: 1) mother-infant dyads enrolled in the NOURISH study, and 2) mother-infant dyads enrolled in the SAIDI study. NOURISH is a multi-centre, randomised controlled trial evaluating the efficacy of a community-based intervention that encouraged positive feeding practices that promote healthy infant food preferences and intakes (Australasian Clinical Trials Registration ACTRN 1260800056392)[15]. NOURISH enrolled primiparous mothers only, and was conducted in two Australian cities (Brisbane, Queensland and Adelaide, South Australia). The SAIDI study, a longitudinal study investigating the dietary intake of South Australian infants, included both primi and multiparous mothers recruited in metropolitan (Adelaide) and regional South Australia[16]. This study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures involving human subjects were approved by eleven Human Research Ethics Committees covering Queensland University of Technology, Flinders University and all the recruitment hospitals (Queensland University of Technology HREC 00171 Protocol 0700000752.) Written informed consent was obtained from all families.

Studies were conducted concurrently and mainly used common protocols. A two-stage recruitment process was used; Stage 1 being within 72 hours of delivery and Stage 2 after 3-7 months for final consent. Further details have been reported[15-17]. Consenting mothers at Stage 1 completed a questionnaire providing socio-demographic information, including age, education level (categorised as less than Year 10, Year 10/11, Year 12, Trade/Apprenticeship, Technical and Further Education(TAFE)/College certificate, University degree), marital status (categorised as single/never married, married, defacto, separated/divorced, widowed) and self-reported pre-pregnancy weight status (categorised as underweight, normal, overweight or don't know). Child gender and maternal parity were collected from medical records. Data collected at Time 1-3 included age solids first introduced and breastfeeding duration. Breastfeeding duration was categorised as: never; less than 6 months; 6-12 months, and more than 12 months. Participating mother-infant dyads provided data at three points, referred to as Time 1 (aged 3 to 9 months), 2 (aged 11-17 months) and 3 (aged 23-27 months). At each time, mothers completed a questionnaire, the infant was weighed and measured and a telephone 24-hour food recall and two day food record were collected.

Data collected as part of the questionnaire included demographic information, infant feeding information and maternal food preferences

Anthropometric measurements were taken by trained study staff, or if residing in a regional area, by the GP or local health clinic. Outer clothing was removed, with clean nappies, underwear and singlets permitted. Infant scales and a measuring mat were used at Time 1 and 2, while standing

scales and a stadiometer were used at Time 3. Weight-for-age at Time 1 and Body Mass Index (BMI) were calculated according to World Health Organisation (WHO) 2006 Growth Standards using the WHO Anthro software program version 3.0.1 and macros[18].

Mothers were asked to identify times that were unsuitable to be telephoned to conduct the 24-hour food recall. Unsuitable times were identified in order to maximise successful contact but avoid mothers being alerted to the day of the recall to facilitate the recall reflecting usual intake. The 24-hour food recall was conducted by trained study dietitians via telephone following standard multiple-pass methodology[19] either one to two weeks after (NOURISH) or before/after (SAIDI) the anthropometric measurements were taken. Mothers were asked to recall everything their infant ate or drank in the previous 24 hours, starting from midnight on the previous day. On completion of the 24-hour recall mothers were assigned two days on which to keep a 24-hour record of everything their child ate or drank. These days were selected according to the day on which the recall had been completed with the aim of allocating two week days and one weekend day to each infant and all days of the week represented across each of the studies. A food record pack was provided that included a set of measuring spoons, a measuring sheet with life-size images of different spoon sizes, food record booklet for recording the infant's intake and a food record booklet to be given to any carers who may give food to the infant during the recording period. Household measures (metric cup, tablespoon and teaspoon) were used to estimate serve size. For dishes prepared at home mothers were asked to provide the recipe with ingredient quantities, and the amount the infant consumed. The time of each eating occasion was also recorded.

A reply-paid envelope was provided for return of the completed food record booklet. On receipt of the records, study staff checked them for any obvious omissions and uncertainties and if necessary, contacted the mother for clarification.

Food intake data handling:

The 24-hour recall and the two 24-hour records were handled as separate files for data entry. All items were entered into FoodWorks Professional version 9 using the AUSNUT 2007 database from the National Children's Nutrition and Physical Activity Survey[20]. The database includes a very limited number of infant formulae and commercial infant food products. As these items were commonly recorded in food recalls/records, nutrient profiles for additional products were added to the FoodWorks database by study staff. Nutrient information was sourced from the internet (e.g. from food manufacturer websites), directly from the food manufacturer or nutrition information

panels on products available in the supermarket. Generally a macronutrient profile with limited information on micronutrients was available for commercial infant foods while for infant formulae a full nutrient profile was available. Iron content was not available for approximately one third of commercial infant foods. The amount of food consumed from home-prepared dishes was calculated as a proportion of the total amount of food prepared. If a home-prepared dish contained five or more ingredients the dish was added to FoodWorks as a recipe, otherwise the appropriate proportions of ingredients were entered as individual items.

A comprehensive protocol for checking FoodWorks data entry was implemented and included inspection of (i) the quantities of food and drink consumed, and (ii) total energy and macronutrient intakes. Any suspicious (i.e. potentially erroneous) entries were checked against the hardcopy recall/record and either corrected if possible or omitted.

Data were exported from FoodWorks into an Access database and merged with a file that assigned a unique eight digit food code to every food item. These codes were available from Food Standards Australia New Zealand (FSANZ) for all items in the AUSNUT 2007 database[20]. New foods (e.g. commercial infant products, infant formulae) added to FoodWorks by study staff were assigned an appropriate code. For recipes that included items from a number of food groups e.g. a mixture of infant cereal, milk and fruit, the food group code assigned was based on the item that made the greatest contribution by weight in addition to identifying that it was a mixed dish. Australian food labelling regulations require all commercial food labels to list ingredients in descending order of ingoing weight, facilitating the identification of the main ingredient of a mixed dish and its subsequent food group code. Once completed, the Access database was imported into SPSS versions 18 and 19 (as this became available for T2) for analysis. For some outcomes the T1 sample was divided into three age bands to make data more meaningful and relevant to infant development. These bands were Group 1: up to but not including 4 months (< 122 days), Group 2: 4 months up to but not including 6 months (122 – 181 days inclusive), and Group 3: 6 months or older (182 days or more).

Defining and identifying meat and meat alternatives consumption:

Throughout this paper (unless otherwise specified), ‘meat’ refers to flesh, ‘BLV’ refers to beef, lamb and veal, and ‘meat alternatives’ refers to eggs, legumes, nuts and seeds. The term ‘meat/meat alternatives’ (M/MA) is used to refer collectively to flesh and alternatives to flesh, that are also

valuable sources of protein, iron and zinc (for example eggs, legumes, nuts and seeds). In order to better describe intake, M/MA were grouped by type and presentation (see Table 1).

Data analysis:

Only participants providing all three days of food intake data were included in this analysis, as this provides a broader account of M/MA intake than one day. At Time 1, the sample was limited to only those infants who consumed solid food at least once in the three days.

Maternal education and marital status were collapsed due to small numbers in some categories. Maternal education groupings included: less than Year 10, Year 10/11 and Year 12 = 'up to Year 12', Trade/Apprenticeship and Technical and Further Education(TAFE)/College certificate = 'Trade/TAFE', and 'University degree'. Marital status groupings included: single/never married, separated/divorced and widowed = 'Single, widowed, separated or divorced', and married and de facto = 'married/de facto'.

Frequency of intake is reported as the number of times a particular item was consumed across the three days (reported as 'occasions' in the tables), and the number of consumers. The former is often greater than the latter as one consumer may have the same M/MA type more than once. Therefore for the purpose of this paper, 'consumer' refers to a participant that consumed any of the relevant food on at least one occasion in three days. Where there was a combination of M/MA in the one mixed dish, the M/MA that made up the larger portion was considered. An average serve size was calculated per consumer for each M/MA type, and of these results, the median and interquartile range (IQR; where the number of consumers was $\geq$ 4) is presented. Because each consumer may have had multiple serves of a particular type of M/MA (for example one child had 14 serves of a variety of seeds across three days) an average serve size for each consumer was calculated so as not to skew the median toward any one individuals usual serve size. Note that in the case of processed M/MA the median quantity consumed is inclusive of other ingredients (eg breadcrumbs, fillers, sauces, spices), whereas all other figures represent the M/MA portion of the meal only (see Table 1). In order to calculate the M/MA portion of a mixed dish, all recipes were screened for the proportion of M/MA by weight as they were entered. From this, an average proportion of M/MA was determined and applied to the gram quantity of the total amount of dish consumed. Similarly for infant foods, proportion of M/MA was taken from a number of available ingredient lists (food manufacturer or websites) of commercial infant foods popular with the sample population, and an

average proportion derived. BLV and poultry based infant food products were calculated to be on average 10% meat, whereas fish based products were calculated to be only 8%.

Results:

Demographic data are presented for the Time 2 sample only (Table 2), as this point included the largest sample size (600 compared with 482 and 533 at Time 1 and 3 respectively). Results were similar when looking at Time 1 and 3 data, except for number of university educated (T1, 2 & 3; 47, 58 & 62% respectively), and first-time mothers (T1, 2 & 3; 68, 77 & 77% respectively). The mean (SD) age of children at Time 1 was 5.5(1.1) months (n=482), and according to age band was 3.6(0.3) months for Group 1 (n=50), 5.2(0.6) months for Group 2 (n=262) and 6.5(0.5) months for Group 3 (n=170). The mean (SD) age of children at Time 2 and 3 was 14.0(1.2) months (n=600) and 24.0(0.7) months (n=533) respectively.

The mean (SD) weight and height of children at Time 1 (n=477) was 7.4 (1.0)kg and 66.4 (3.1)cm respectively. Weight and height at Time 1 according to age band was 6.6 (0.7)kg and 63.0 (2.2)cm for Group 1 (n=50), 7.4 (0.9)kg and 66.0 (2.6)cm for Group 2 (n=262) and 7.8 (0.9)kg and 68.0 (3.1)cm for Group 3 (n=165). The mean (SD) weight and height of children at Time 2 (n=587) and 3 (n=526) was 10.3(1.2)kg and 77.9(3.2)cm, and 12.8(1.6)kg and 86.9(3.3)cm respectively. The mean (SD) BMI z-score was 0.3(0.9) at Time 2 (n=585) and 0.8(1.0) at Time 3 (n=526).

Intake of M/MA:

Time 1: 3 – 9 months (n=482):

Mean age 5.5 (1.1) months. At Time 1, 58.4% of infants (n=482 of 825) consumed solid food. Table 3 presents the intake of M/MA over three days according to M/MA type and presentation. The sample is presented according to age group and as a full sample. Group 1 was not presented (except for inclusion in the 'total' sample) as M/MA consumption was rare in infants aged less than four months.

Meat present in commercial infant foods was the most common form of consumption of M/MA by infants at this time. The most frequently consumed source of M/MA was BLV-based commercial infant foods (77 occasions of consumption by 45 consumers), followed by poultry-based commercial infant foods (57 occasions by 37 consumers) and pure cuts of poultry (56 occasions by 34 consumers). Children in the Group 3 age band consumed more of these types of meat than those

in Group 2. For red meat based commercial infant foods there were 48 occasions of consumption by 27/170 infants in Group 3 compared to 26 occasions of consumption by 17/262infants in Group 2. Pork, fish and seafood, legumes and eggs were seldom consumed by any infants at Time 1 and nuts and seeds were not consumed at all.

For those children consuming BLV, median (IQR) serve sizes were largest when consumed in the form of a pure cut (16.1 (6.6:25.5)g of meat per serving), followed by mixed dishes (10.5 (4.2:17.2)g of meat per serving) and then commercial infant foods (8.5 (5.7:12.0)g of meat per serving). Similar patterns emerged for the consumption of the various forms of poultry.

Time 2: 11 – 17 months (n=600):

Mean age 14.0 (1.2) months. At Time 2 the most commonly consumed M/MA were: BLV mixed dishes (452 occasions of consumption by 289 consumers), followed by pure cuts of poultry (221 occasions by 179 consumers), poultry based mixed dishes (220 occasions by 152 consumers) and egg based mixed dishes (217 occasions by 134 consumers) (Table 4).

From Time 1 to Time 2, the median serve size of pure BLV doubled, and that of mixed BLV dishes almost tripled (Table 4). The serve sizes of most other M/MA increased over this period. Most notable was the processed forms of M/MA, which were generally not consumed at all at Time 1, whilst at Time 2 were consumed in the largest quantities (for example, median (IQR) serve size for processed fish/seafood was 50.0 (32.3:75.0)g, and for processed legumes was 68.8 (22.0:114.4)g).

Time 3: 22 – 27 months (n=533):

Mean age 24.0 (0.7) months. At Time 3 the most commonly consumed form of M/MA was still BLV mixed dishes (301 occasions of consumption by 237 consumers) (Table 4). Processed pork products (principally ham) were also very popular (302 occasions by 203 consumers). Of note at this time is the increased popularity of miscellaneous processed meat (including devon/fritz and frankfurts).

The median (IQR) serving size of processed legumes was the largest (66.6 (31.7:130.0)g per serving), with processed fish/seafood and poultry, followed by pure eggs and processed BLV being consumed in the next largest portions (Table 4). Processed BLV (including sausages, patties, meatballs, rissoles and cold cuts) was the form of BLV consumed in the largest portions at Time 3.

Popularity across time points:

Some of the most popular M/MA at Time 3 demonstrating the greatest change over time are presented graphically in Figure 1. The greatest increase in popularity from Time 1 to Time 2 was for BLV-based mixed dishes from 4% to 48% of participants, however by Time 3 this figure had dropped slightly to 45% (see Tables 3 and 4). Of note is the increase in popularity of processed meat products from Time 1 to Time 3, led by processed pork (principally ham). Other noteworthy results include the increased popularity of eggs (both pure and in mixed dishes) by Time 2, and the reduced popularity of commercial infant foods containing meat.

The most popular processed M/MA of each group are described in Table 5. As processed M/MA were rarely consumed at T1, this point is excluded. Of the processed pork products, ham was the most popular making up around 80% of the consumptions at Time 2 (152 of 183) and 3 (237 of 302). Peanut butter was also very popular (with 109 occasions of consumption at T2 and 158 at T3), followed by BLV sausages (93 at T2 and 117 at T3). The largest increase in popularity was that of chicken nuggets, which made up almost 27% of processed poultry consumptions at T2, increasing to almost 39% of consumptions at T3. The decreased percentage of consumptions of devon/fritz was caused by an increase in the consumption of unspecified varieties of salami, frankfurts and sausages.

Comparison with Dietary Modelling:

Table 6 presents the Australian Dietary Guideline modelling for M/MA for the age groups six to 12 months, and 13 to 36 months[3]. The modelling suggests serving size and number of servings per week. The present study collected data for only three days of intake, therefore a gram quantity per three days was calculated from the dietary modelling which was used to determine the number of infants and young children meeting the recommendations.

According to the modelling (Table 6), infants aged between six and 12 months should consume four 30g serves per week (equating to 51g in three days) of BLV and/or pork. Of the 170 infants aged at least 6 months (mean(SD) age 6.5(0.5) months) and consuming solids, only 50 (29%) consumed BLV/pork on at least one of the three days, and only two of these infants consumed a total amount (across three days) of BLV/pork greater than or equal to 51g.

Additionally, it is suggested that infants of this age consume two 30g serves per week (equating to 26g in three days) of poultry, fish, seafood, eggs and/or legumes (excluding nuts and seeds). The proportion of infants consuming poultry, fish, seafood, eggs and/or legumes was greater than the proportion consuming BLV/pork, at 41% (69/170). More infants (14% compared to 1% for BLV/pork) consumed at least 26g across the three days. Although it is worth noting that only 16% (27/170) of infants consumed items from both these groups in the three days of intake.

It is recommended that children aged between 13 to 36 months consume 65g of BLV/pork 3.5 times per week, or 98g in three days (Table 6)[3]. Of 600 children (mean(SD) age 14.1(1.2) months), 84% (502) consumed BLV/pork at least once during three days. At T3 (mean(SD) age of 24.0(0.7) months) this proportion remained unchanged (450 of 533, 84%). At Time 2 and 3 respectively, 120 (20%) and 156 (29%) consumed at least 98g across the three days.

It is somewhat more difficult to determine if children of this age are meeting the recommendations for poultry, fish, seafood, eggs and/or legumes, as the serve size varies depending upon the type of M/MA consumed. Consumption of 3.5 serves per week of an amount nutritionally equivalent to a 65g serve of red meat (eg 80g of poultry, 100g fish, 2 eggs or 170g legumes) is recommended. Using the weight of one serve of poultry (80g), a crude amount of 120g in three days was calculated. Therefore it is important to note that the proportion of children meeting the requirements would be lower if intake was converted to red-meat equivalents. At Time 2 518/600 (86%) consumed at least some poultry, fish, seafood, eggs and/or legumes in three days, compared to 479/533 (90%) at Time 3. Only 28% (169/600) at Time 2 and 37% (198/533) at Time 3 managed to consume at least 120g of poultry, fish, seafood, eggs and/or legumes combined in three days.

At Time 2, there were 433 (of 600, 72%) consuming both BLV/pork and poultry, fish, seafood, eggs and/or legumes, while at Time 3 there were 400 (of 533, 75%). However a mere 5% (31 of 600) at Time 2 and 11% (57 of 533) at Time 3 met the recommended intake across three days for both BLV/pork and poultry, fish, seafood, eggs and/or legumes.

Discussion:

This study presents new data regarding the frequency, amount and nature of M/MA consumption in Australian children aged two years and under. It found that in a large sample of Australian children aged less than 9 months, consumption of M/MA was primarily in the form of commercial infant foods, which provided only small amounts of meat (generally BLV or poultry). When M/MA were consumed in pure form or a mixed dish, the median serving size of meat was greater. As infants

aged, M/MA intake increased and was primarily in the form of mixed dishes and pure cuts rather than commercial infant foods. However by the age of two years, processed forms of meat (such as ham and sausages) had increased in popularity.

The proportion of consumers of BLV or pork improved considerably by Time 2 (from 30% to 84%), but the majority did not consume quantities sufficient to meet guidelines. By Time 3, the same proportion were consuming BLV or pork as at Time 2 (around 84%), but a greater number of children were consuming a minimum of one 'serve', although still less than half the children (44% at Time 3 versus 35% at Time 2). The proportion of consumers of poultry, fish, seafood, eggs and/or legumes at Time 2 and 3 approached 90%. While it is difficult to compare median intake to guidelines as each of poultry, fish, seafood, eggs and/or legumes have different suggested serving sizes, it is clear that very few children (if any) met recommendations.

Only one previous Australian study has reported meat intake in infants and toddlers (Childhood Asthma Prevention Study (CAPS))[21]. Based on 1563 meals from 429 18-month-old children, meat was consumed, on average, just over once per day. Consumption of meat, cereal-based meat products, and infant foods was reported in detail but not the consumption of seafood, or meat alternatives (eggs, legumes or nuts and seeds). The age of the CAPS study sample falls between Time 2 and Time 3 of the current study, therefore direct comparison of intake is difficult as this is a period of rapid change in eating patterns and food preferences. In general however, the most commonly consumed forms of meat and the serve sizes in which they are consumed were similar. US data from the Feeding Infants and Toddlers Study (FITS) is again difficult to compare directly to these results as age groups differ, and M/MA are grouped differently. FITS included only selected M/MA, and these differed by age group. They did however find that in the younger age groups (4-6,7-8 months), M/MA were most commonly consumed as commercial infant foods, as in the present study[22]. Infants were aged at least nine months before non-commercial infant food M/MA became more popular[22].

This study demonstrates that the most common way to consume M/MA in the 4-9 month old age group is as BLV and poultry based commercial infant foods. Typically, BLV in this form is part of a "mixed dish" and as such the serving size is smaller than if offered as a discrete food. In addition, as these commercial infant foods include multiple ingredients, the BLV's flavour and texture is likely to be well 'disguised'. To the knowledge of the authors, meat-only (or majority meat) infant foods are not widely available in Australia, unlike in some European countries (for example: a popular European range of meat based infant food contains approximately 30% meat, with water, cornstarch or rice, salt and lemon juice)[23]. Typically, meat and vegetable based commercial infant foods are predominantly made up of vegetables with around 10% meat. This blend results in a

product that is unrecognisable as meat-containing, particularly when in a pureed form. FITS data showed that commercial infant foods were the primary source of vegetables, fruits and meat in infants aged up to 7-8 months[22]. Commercial infant foods tend to be of a consistent texture and appearance (which is difficult to achieve when preparing food at home) which can limit the sensory variety in a child's diet. Therefore, a high consumption of and reliance on commercial infant foods may limit a child's acceptance of new foods and tolerance of textures[24]. Exposure to discrete flavours is crucial for children to gain the ability to recognise and accept new and different foods[25]. This in turn impacts on food preferences and longer term health[26]. In addition, exposure to varied textures including lumps and larger pieces of food (for self-feeding), particularly between 6 to 10 months is important for developing oral-motor skills[27,28]. The FITS data discussed earlier, resulted in a recommendation that parents offer meat as a plain, home-prepared puree from as early as six months of age[22].

In the current study, as children aged, the consumption of pure egg and processed pork and BLV increased. It is important to note that egg consumption reported as "mixed dishes" mostly described the consumption of eggs when used in baking (ie. cakes and biscuits) and as such serving sizes were small. Whole eggs were not meaningfully consumed until children were over nine months of age (n=2 in the 6-9 month old age group). This may reflect practices in line with previous Australian recommendations to delay the introduction of eggs (and other highly 'allergenic' foods) to prevent the onset of allergy. Current recommendations from the Australasian Society of Clinical Immunology and Allergy (ASCIA) state that "there is insufficient evidence to support previous advice to specifically delay or avoid potentially allergenic foods for the prevention of food allergy or eczema"[29]. This position is supported by the American Academy of Allergy, Asthma & Immunology and the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition[30,31]. This may illustrate the need for increased dissemination of this message to ensure health professionals and parents are aware of these new guidelines.

The increased consumption of processed meat from Time 1 to Time 2 (BLV) and Time 1 to Time 3 (pork) was due to a greater number of children consuming products such as cold cuts of meat (principally ham) and sausages. These meat products are typically higher in sodium than unprocessed meat products, exposure to which can increase an infant's preference for salty foods[32], consumption of which is linked to hypertension, heart disease and stroke in later life[33]. In the UK, children aged 12 to 18 months have a mean intake of 181% of the RNI (reference nutrient intake) for sodium, or 2.3g of salt per day. Additionally, the National Heart Foundation recently released data reporting that Australian children aged 5 to 13 years are consuming as much salt as adults (6g/day), 75% of this being provided by manufactured foods[34] of which the aforementioned

meat products make a small but avoidable contribution. These softer forms of meat are probably better accepted by toddlers while they are still developing efficiency with chewing[35]. However, this is no reason to avoid the possibly tougher textures of pure BLV, pork or poultry, as oral-motor skills develop as children are challenged with various textures[25].

Legume consumption increased over time, most commonly in the form of baked beans. While most likely as part of an omnivorous diet, it must be remembered that vegetarianism is becoming increasingly popular amongst adults and hence more children are also following this eating pattern[36]. It could not be confirmed if the same is the case in the present paper as vegetarianism was not investigated.

Our data show that in the early stages of complementary feeding daily intakes of BLV/pork in Australian infant's falls well short of recommendations. Importantly, although intake increased with age, this increase was in both pure cuts and dishes, and processed BLV/pork products, which are typically higher in sodium and lower in actual meat content. Infants were somewhat closer to meeting the guidelines regarding poultry, fish, seafood, eggs and/or legumes, with around one third of infants aged 12-24 months meeting the Australian recommendations. It is likely that a combination of factors account for the low intake of BLV/pork in infancy, including the use of commercial infant meals containing BLV or poultry (as meat is found in low concentration in these products), parental anxiety regarding gagging and choking, uncertainty regarding food preparation for infants and social/cultural influences (ie it is not 'usual' to introduce meat in the early stages of complementary feeding). One implication of the low number of children meeting requirements may be increased risk of iron deficiency. However it must be noted that iron intake is not only dependent upon M/MA intake, and that other iron sources such as cereal products and formula intake play an important role, particularly in the intake of infants and young children[8].

Two of the strengths of this study are the categorisation of food sources within the M/MA food group and the detail to which this process has been described, which better allows comparison with other research. In addition, to the knowledge of the authors, it is the only study to report the dietary intake of M/MA of a large sample of Australian children aged less than two years of age.

Families participating in this study do differ from the general population in that they volunteered to participate in an infant feeding intervention or survey, were more highly educated and more likely to be in a relationship than the broader Australian population. Recent Australian Bureau of Statistics (ABS) data suggests that around 40% of Australian women aged between 30 and 34 years hold a Bachelor degree or higher, compared to 58% in the current sample[37]. Research in the UK has shown that in children aged 12 to 18 months, there was an increasing number below the lower

reference nutrient intake (LRNI) for iron with decreasing socioeconomic category (based on employment type)[8]. Interestingly, the sources of iron were similar despite socioeconomic category except for commercial infant foods which contributed around 11.6% of iron intake in the highest category compared to 11.0% in the lowest, and fish and fish dishes (5.5% versus 4.8%)[38]. This demonstrates that the difference in socioeconomic status seen between the present paper and the general population in Australia may have an effect on the generalizability of the present results. Additionally, in 2006, just under 60% of Australian adults aged 25 to 34 years were in a relationship (married or de facto), compared to 97% of parents involved in the present study[39]. It must also be recognised that the generalizability of results and recommendations to other countries is limited due to the sample being exclusively Australian.

Conclusion and recommendations:

Detailed dietary data as presented in this paper enables a greater understanding of not only the M/MA intake of a population of Australian infants and toddlers but also how this consumption compares with Australian dietary guidelines. Assessing intake of infants and toddlers at the food rather than nutrient level provides a better understanding of the pattern of intake which may be contributing to risk of certain deficiencies associated with that food group. It also enables us to develop dietary and behavioural advice that is both meaningful and relevant to the Australian population, but may also be useful for other populations with similar dietary habits. As such, it is recommended that:

- M/MA and particularly BLV are offered as one of the early complementary foods, starting from six months of age.
- Infants are offered M/MA primarily in pure form or as home-prepared mixed dishes rather than as commercial infant foods, as this supports infants to meet recommended daily intakes of M/MA. This may in turn aid toddlers' acceptance of pure M/MA, and reduce reliance on higher salt meat products.
- Parents are encouraged to introduce new and challenging textures at appropriate developmental stages, to ensure oral-motor skill development in their children. This may include pure forms of M/MA in lumps (for chewing) and larger pieces (for self-feeding) as appropriate.
- Education and health promotion programs targeted at parents of infants and toddlers include messages about the most appropriate types of M/MA (along with information regarding the

other core food groups; wholegrain breads/cereals, vegetables, fruit and dairy products) and how to prepare and present them.

Acknowledgements:

The authors would like to acknowledge the input of Jo Meedeniya, Rebecca Byrne, Jacinda Wilson, Kylie Markow and Rachel Elovaris towards data collection and entry. Thankyou to the many parents and children involved in the NOURISH and SAIDI studies.

Financial support:

NOURISH was funded 2008–2010 by the Australian National Health and Medical Research Council (grant 426704). Additional funding was provided by Meat and Livestock Australia (MLA), HJ Heinz, Department of Health South Australia, Food Standards Australia New Zealand (FSANZ) and Queensland University of Technology.

Conflicts of interest:

None

Authorship:

The contribution of each author to the paper was as follows: CM planned and conducted data analysis; CM and RP planned and wrote the paper; LD and AM contributed to the original planning of the research studies NOURISH and SAIDI, and commented on drafts. All authors read and approved the manuscript for publication.

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Figure 1: The changing popularity over time of six of the most popular M/MA using only those participants that provided all three days of data at every time point (N=452). BLV mixed dishes showed the largest increase in popularity from Time 1 to Time 2, however, unlike other meat types, this trend did not continue from Time 2 to 3. Processed pork, which was not consumed at Time 1, became the second most popular M/MA at Time 3, surpassing even pure cuts of poultry (which was the most popular pure M/MA at Time 1).

1 Table 1: M/MA grouped by presentation and type

	Presentation	Pure: Pure cuts of M/MA only	Processed: Processed M/MA which may include binders, herbs, spices, salt and sauces	Mixed dishes: M/MA consumed as part of a recipe with multiple ingredients	Commercial infant foods: Pre-prepared, packaged (tins, jars & sachets) infant meals including M/MA
M/MA type	BLV: beef, lamb, veal	Steak/fillets Cutlets Mince meat (where not in a 'mixed dish')	Sausages Patties/meatballs/burgers Crumbed/battered Deli meat	Bolognaise/lasagne Casserole/stew/curry Risotto Pies Soups	Usually a mixture of meat (approx. 10%) vegetables and cereals
	Pork	Steak/fillets Cutlets Mince meat (where not in a 'mixed dish')	Sausages Patties/meatballs/burgers Crumbed/battered Deli meat (ie ham, bacon, prosciutto)	Bolognaise/lasagne Casserole/stew/curry Risotto Pies Soups	N/A
	Poultry: chicken, duck, turkey, quail	Breast fillet Thigh fillet Wing/leg Mince meat (where not in a 'mixed dish')	Sausages Patties/meatballs/burgers Chicken nuggets Crumbed/battered Deli meat	Bolognaise/lasagne Casserole/stew/curry Risotto Pies Soups	Usually a mixture of meat (approx. 10%) vegetables and cereals
	Fish & seafood: fish, shellfish, molluscs	Fillets/whole Plain tinned (in brine, water, oil or minimal flavour)	Crumbed/battered Fish fingers Smoked	Fish cakes (due to high vegetable content) Mornay/risotto Sushi	Usually a mixture of meat (approx. 8%) vegetables and cereals
	Eggs	Boiled, poached & fried Simple omelettes & quiches	N/A*	Quiche/frittata (with many ingredients) Fried rice Baked goods (cakes/muffins)	N/A
	Legumes	Dried Tinned (drained) in water/brine	Baked beans Hommus Falafel Tofu	Stews/casseroles Soups Curry/dahl	N/A

	Nuts & seeds	Whole nuts/seeds (including roasted, salted)	Peanut butter Tahini	Baked goods (cakes/muffins) Cereal/porridge	N/A
	Miscellaneous meat	Brain Liver Stomach Game meat (goat, kangaroo, rabbit)	Devon/fritz Frankfurts/hot dogs Salami Pate	Dim sims Meat filled pasta (unknown meat)	N/A

1 *Not applicable

Table 2: Demographic data for those providing all three days of food intake data at Time 2 (n=600)

Demographic variable	N*	Percent	Mean	SD
Marital status				
Single, widowed, separated or divorced	17	3		
Married/de facto	582	97		
Mother education				
Up to year 12	103	17		
Trade/TAFE	147	25		
University	350	58		
Mothers self-reported pre-pregnancy weight status				
Underweight	13	2		
Normal	483	81		
Overweight	101	17		
Don't know/no answer	3	1		
Parity				
Only child	461	77		
Child gender				
Male	272	45		
Mother's age at child's birth (yrs)	599		31	5
Child age (months)	600		14	1
Child weight (kg)	591		10	1
Child height (cm)	587		78	3
Child BMI z-score	585		0.3	0.9

* Numbers may not add up to N value due to missing or incomplete data for some variables (range 585 – 600).

Table 3: Consumption of M/MA at Time 1 by infants enrolled in the NOURISH and SAIDI studies

M/MA	Group 2: 4 to <6 months (N = 262)†		Group 3: 6 to <9 months (N = 170)†		TOTAL sample: 3 to <9 months* (N = 482)†		
	Occasions‡ (consumers§)	Median (IQR) serve size – g ǀ	Occasions‡ (consumers§)	Median (IQR) serve size – g ǀ	Occasions‡	Consumers § (%)	Median (IQR) serve size – g ǀ
BLV							
Pure cuts	6 (4)	28.4(19.3:40.9)	23 (14)	8.7(5.5:19.7)	29	18 (3.7)	16.1(6.6:25.5)
Processed	0	-	0	-	0	0.0	-
Mixed dishes	10 (6)	15.8(6.4:25.4)	17 (12)	6.7(3.5:19.1)	27	18 (3.7)	10.5(4.2:17.2)
Commercial infant foods	26 (17)	8.5(6.0:11.5)	48 (27)	8.0(5.6:12.0)	77	45 (9.3)	8.5(5.7:12.0)
Pork							
Pure cuts	0	-	1 (1)	6.0 (-)	1	1 (0.2)	6.0 (-)
Processed	0	-	0	-	0	0.0	-
Mixed dishes	0	-	1 (1)	16.7 (-)	1	1 (0.2)	16.7 (-)
Poultry							
Pure cuts	14 (8)	13.7(3.9:18.6)	42 (26)	15.1(6.9:32.6)	56	34 (7.1)	15.0(6.9:26.8)
Processed	0	-	0	-	0	0.0	-
Mixed dishes	8 (5)	12.4(6.3:17.0)	23 (13)	19.2(6.5:25.2)	31	18 (3.7)	14.6(6.8:22.4)
Commercial infant foods	13 (10)	6.5(3.6:12.7)	40 (24)	6.6(5.2:11.0)	57	37 (7.7)	6.0(5.0:11.0)
Fish & seafood							
Pure cuts	5 (3)	5.0(-)	11 (5)	20.8(3.6:27.6)	16	8 (1.7)	5.8(3.0:22.3)
Processed	0	-	0	-	0	0.0	-
Mixed dishes	1 (1)	15.5 (-)	5 (5)	36.7(9.7:41.6)	6	6 (1.2)	26.1(11.0:40.5)
Commercial infant foods	2 (2)	5.6 (-)	8 (6)	2.7(1.5:10.2)	11	9 (1.9)	3.1(1.9:9.0)
Eggs							
Pure	1 (1)	12.0 (-)	7 (6)	11.1(0.9:24.4)	8	7 (1.5)	12.0(1.0:20.5)
Mixed dishes	0	-	0	-	0	0.0	-
Legumes							
Pure	2 (2)	14.0 (-)	5 (4)	23.4(10.6:41.2)	7	6 (1.2)	18.0(10.9:31.6)
Processed	0	-	7 (5)	34.3(10.7:59.8)	7	5 (1.0)	34.3(10.7:59.8)
Mixed dishes	1 (1)	22.9 (-)	2 (1)	7.6 (-)	3	2 (0.4)	8.6(-)
Nuts & seeds							
Pure	0	-	0	-	0	0.0	-
Processed	0	-	0	-	0	0.0	-
Mixed dishes	0	-	0	-	0	0.0	-
Miscellaneous meat							
ALL¶	1 (1)	3.5 (-)	7 (4)	6.4(2.6:13.0)	8	5 (1.0)	4.4(2.7:11.4)

* Includes infants aged less than 4 months.

†'Participants' includes ONLY infants in that age category that consumed solids at least once in the three day period.

‡ Occasions = number of times any item from that group was recorded across the three days

§ Consumers = number who consumed an item from that group on at least one of the three days

ǀ Median of all consumers average serve size.

¶ Due to the small number of miscellaneous meat consumed, all pure cuts (eg pure offal), processed (eg frankfurts) and mixed dishes (eg dumplings) were grouped together.

Table 4: Consumption of M/MA at Time 2 and 3 by infants enrolled in the NOURISH and SAIDI studies

M/MA	11 – 17 months (n=600)			22 – 27 months (n=533)		
	Occasions*	Consumers (%)†	Median (IQR) serve size – g‡	Occasions*	Consumers (%)†	Median (IQR) serve size – g‡
BLV						
Pure cuts	146	120 (20.0)	31.2(16.9:45.7)	178	145 (27.2)	38.4(22.6:60.0)
Processed	168	141 (23.5)	34.5(18.6:45.8)	202	158 (29.6)	44.0(28.9:58.0)
Mixed dishes	452	289 (48.2)	29.1(17.3:46.4)	301	237 (44.5)	23.9(14.6:50.5)
Commercial infant foods	151	103 (17.2)	12.5(8.5:17.0)	22	16 (3.0)	16.3(8.5:17.0)
Pork						
Pure cuts	32	27 (4.5)	21.0(10.8:40.0)	30	28 (5.3)	37.8(10.8:61.8)
Processed	183	138 (23.0)	17.9(10.0:26.5)	302	203 (38.1)	21.0(13.5:40.0)
Mixed dishes	75	55 (9.2)	7.9(3.3:16.2)	51	46 (8.6)	12.9(8.5:18.8)
Poultry						
Pure cuts	221	179 (29.8)	35.8(16.8:60.0)	248	194 (36.4)	37.0(26.8:71.5)
Processed	98	83 (13.8)	40.0(20.8:56.3)	150	121 (22.7)	49.5(32.5:75.0)
Mixed dishes	220	152 (25.3)	22.9(12.9:35.9)	150	125 (23.5)	30.0(13.4:52.4)
Commercial infant foods	70	55 (9.2)	15.0(8.5:17.0)	10	9 (1.7)	14.5(8.3:22.0)
Fish & seafood						
Pure cuts	116	90 (15.0)	26.4(13.6:50.1)	120	91 (17.1)	36.0(19.2:66.0)
Processed	41	39 (6.5)	50.0(32.3:75.0)	80	65 (12.2)	50.0(32.7:71.0)
Mixed dishes	183	136 (22.7)	22.3(13.9:33.1)	78	73 (13.7)	27.3(13.6:46.3)
Commercial infant foods	35	28 (4.7)	9.6(6.8:13.6)	5	3 (0.6)	13.6(-)
Eggs						
Pure	172	135 (22.5)	39.0(21.1:49.0)	192	142 (26.6)	44.0(30.0:64.0)
Mixed dishes	217	134 (22.3)	8.3(4.2:20.2)	138	99 (18.6)	7.6(3.9:18.9)
Legumes						
Pure	8	7 (1.2)	31.3(10.4:52.5)	10	6 (1.1)	33.1(18.9:49.9)
Processed	134	99 (16.5)	68.8(22.0:114.4)	126	94 (17.6)	66.6(31.7:130.0)
Mixed dishes	53	41 (6.8)	15.8(9.1:35.7)	21	19 (3.6)	27.2(7.0:37.1)
Nuts & seeds						
Pure	8	3 (0.5)	6.0(-)	79	42 (7.9)	8.2(5.0:15.0)
Processed	115	83 (13.8)	5.0(3.1:8.8)	175	108 (20.3)	7.9(4.4:10.5)
Mixed dishes	35	18 (3.0)	2.7(1.2:4.3)	53	27 (5.1)	3.4(1.8:7.1)
Miscellaneous meat						
Pure	3	3 (0.5)	38.4(-)	2	2 (0.4)	36.2(-)
Processed	97	66 (11.0)	21.0(13.1:35.1)	199	140 (26.3)	30.9(20.6:57.0)
Mixed dishes	38	30 (5.0)	12.2(7.2:18.1)	29	28 (5.3)	10.3(6.1:13.7)

* Occasions = number of times any item from that group was recorded across the three days,

† Consumers = number who consumed an item from that group on at least one of the three days.

‡ Median of all consumers average serve size.

Table 5: Most popular processed M/MA at Time 2 and 3 by infants enrolled in the NOURISH and SAIDI studies

Processed M/MA type*	11-17 months (N = 600)			22 – 27 months (N = 533)		
	Occasions (% occasions)†	Consumers‡	Median (IQR) serve size – g§	Occasions (% occasions)†	Consumers‡	Median (IQR) serve size – g§
BLV						
Sausages	93 (55.4)	80	28.7(18.5:44.0)	117 (57.9)	100	44.0(29.0:56.7)
Pork						
Ham	152 (83.1)	114	19.0(10.5:27.0)	237 (78.5)	168	21.0(14.9:42.0)
Poultry						
Nuggets	29 (26.5)	26	32.5(20.0:48.0)	58 (38.7)	47	49.5(38.0:60.0)
Fish & seafood						
Crumbed / battered fish fillet	19 (46.3)	19	50.0(33.0:100.0)	42 (52.5)	37	50.0(27.8:76.5)
Legumes						
Canned baked beans	95 (70.9)	80	85.8(56.0:125.0)	74 (58.7)	64	100.0(67.3:137.5)
Nuts & seeds						
Peanut butter	109 (94.8)	80	5.0(3.1:8.8)	158 (90.3)	103	7.9(4.4:11.3)
Miscellaneous meat						
Devon / fritz	59 (60.8)	37	25.2(14.4:36.3)	80 (40.2)	58	31.5(24.7:56.0)

* Each processed M/MA type is inclusive of all varieties and all cooking methods, ie reduced fat, salt reduced, no added sugar, fried, baked etc.
† Occasions = number of times the item was recorded across the three days; % occasions = (no. of times the item was recorded across the three days / no. of times any 'processed' item from that group was recorded across three days(see Table 4)) * 100.
‡ Consumers = number who consumed the item on at least one of the three days.
§ Median of all consumers average serve size.

Table 6: NHMRC dietary modelling[3]

M/MA	Recommendations				Study sample		
	Age group (months)	Serve weight (g)	Weekly serves	g per 3 days*	Time point	Mean age (SD) months	% consuming recommended g per 3 days (N†)
Beef, lamb, veal, pork	6 to 12	30	4	51	T1	6.5 (0.5)	1 (2/170)
	13 to 36‡	65	3.5	98	T2	14.1 (1.2)	20 (120/600)
					T3	24.0 (0.7)	29 (156/533)
Poultry, fish, seafood, eggs, legumes	6 to 12	30	2	26	T1	6.5 (0.5)	14 (24/170)
	13 to 36‡	65g Red-meat equivalent§	3.5	120	T2	14.1 (1.2)	28 (169/600)
					T3	24.0 (0.7)	37 (198/533)

* 'g per 3 days' = 'Serve weight (g)' (for 'red-meat equivalent', the 80g serve size for poultry was used to calculate a crude value) x 'Weekly serves' x (3/7)
† number of study participants meeting recommended 'g per 3 days' / number participants at time point
‡ as the present study collected data at two time points (T2 and T3) that fall in the 13 to 36 month age group, both time points were compared to the recommendations for the 13 to 36 month age group
§ 80g poultry, 100g fish, 2 eggs, 170g legumes as per dietary modelling[3]

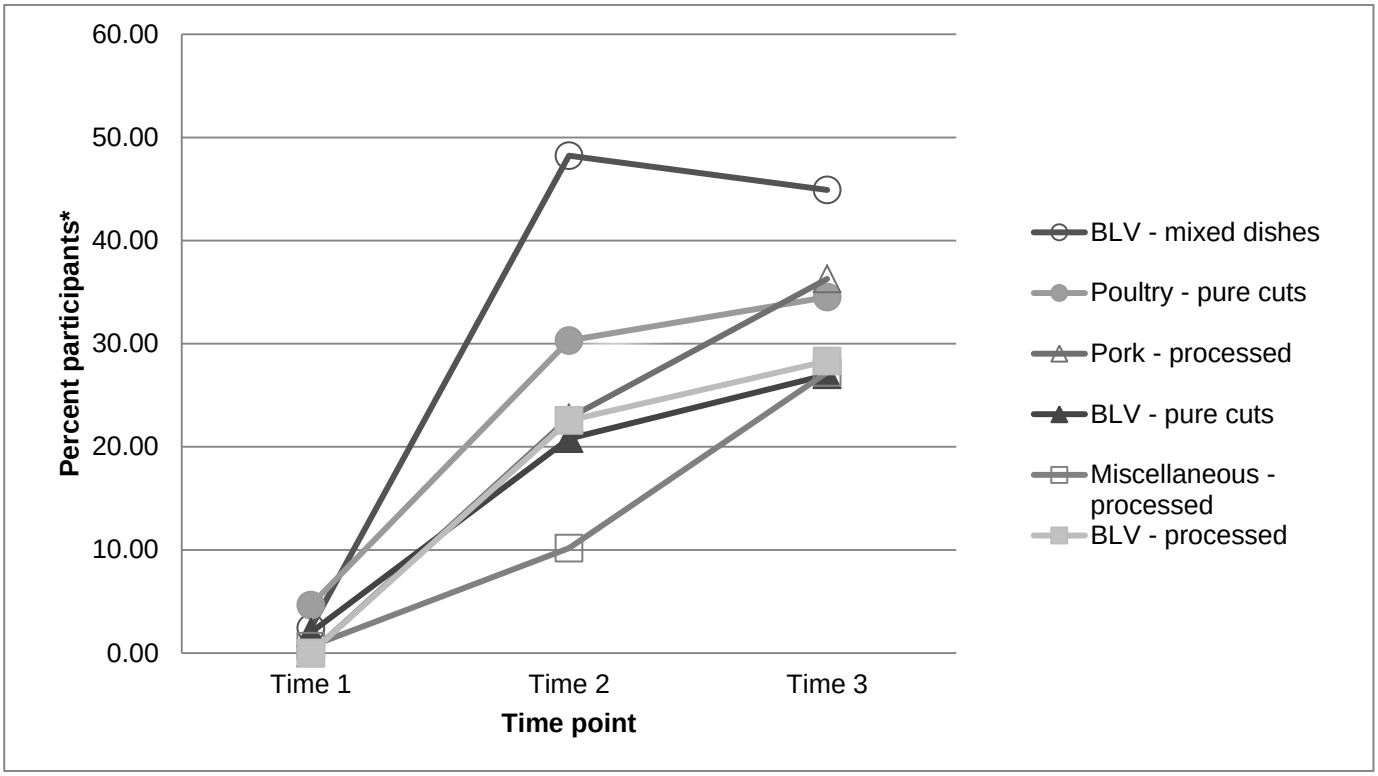
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Percent participants*
Time 1
Time 2
Time 3
Time point
BLV - mixed dishes
Poultry - pure cuts
Pork - processed
BLV - pure cuts
Miscellaneous - processed
BLV - processed

Figure 1